SPIE. SMART STRUCTURES NDE

Portland Marriott Downtown Waterfront Hotel
Portland, Oregon, United States
**25 - 29 March 2017**



# Special Events

## 19th Annual EAP-in-Action Session and Demonstrations

Date: **Sunday 26 March 2017**
Time: **4:30 PM - 5:45 PM**

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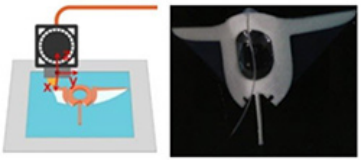
**Part of conference 10163 on EAPAD. Review the full conference program here.**

***Session Chair:*** **Yoseph Bar-Cohen, Jet Propulsion Lab.**

**This Session highlights some of the latest capabilities and applications of Electroactive Polymers (EAP) materials where the attendees are shown demonstrations of these materials in action. Also, the attendees interact directly with technology developers and given "hands-on" experience with this emerging technology. The first Human/EAP-Robot Armwrestling Contest was held during this session of the 2005 EAPAD conference.**

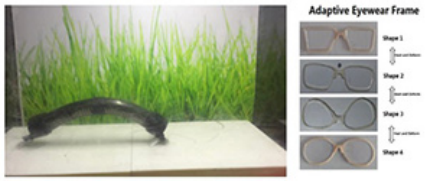
**Tentative EAP Demonstrations**

**Soft robot group with multiple materials and configurations**
**Jing Dai, Bangyuan Liu, Feiyu Chen, Sukai Wang, Zhiqiang Fu, Tiefeng Li, Zhejiang Univ. (China)**



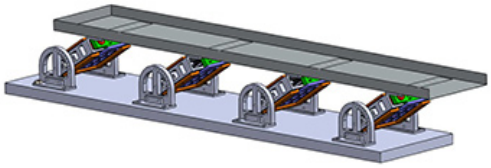
Soft robotics and smart structures will be demonstrated that are made of multiple soft active materials, and can be fabricated by 3D printing method. Driven by dielectric elastomer, the robot shows excellent performances in large actuation and fast response. Using a common compact power and control electronics, various configurations of soft robot can be designed as actuated modules. Smart structures made of temperature active tough hydrogel will also demonstrate as actuators of bio-medical applications. The operation principles may guide the further design of soft robots for various applications.

**Applications of smart deformable polymers**
**Liwu Liu, Jinrong Li, Fengfeng Li, Xiongfei Lv, Xin Lan, Yanju Liu, Jinsong Leng, Harbin Institute of Technology (China)**



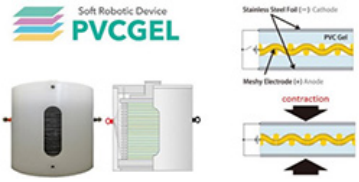

This demonstration will show smart polymers in action taking advantage of their being light weight, fast response, and large deformation. These advantages make them attractive for applications in smart bionics, aerospace, biomedicine and other fields. The demonstration will include the applications of EAP, shape memory polymer (SMP) and pneumatic artificial muscle (PAM), such as soft robot, soft continuum manipulator, smart release device, adaptive eyewear frame and other deformable structures.

**DEA-driven vibratory feeder**
**Steffen Hau, Mathias Hoffmann, Stefan Seelecke, Saarland Univ. (Germany)**



Vibratory feeders are widely used in part handling technology for transport, aligning and/or feeding parts to a certain process. Currently they are driven by electro-magnetic actuators and unbalance motors, which do not allow arbitrary vibration profiles or changes of amplitude / frequency during operation. Dielectric elastomer actuator (DEA) show potential to overcome these drawbacks. A fully functional DEA driven vibratory feeder transporting small goods will be demonstrated, showing DEAs potential in this new field of application. Picture is showing a CAD model of the feeder consisting of transport channel (grey) with four actuator modules underneath.

**Multilayered PVC gel artificial muscle**
**Minoru Hashimoto, Yi Li, Aya Suzuki, Hanako Niwa, Rina Yokotsuka, Shinshu Univ. (Japan)**

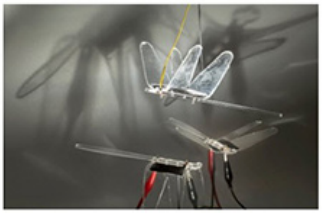



Multilayered contraction type PVC gel actuator was developed using stainless mesh electrodes having many positive characteristics. This include being soft and lightweight, with stable actuation in air and with high output. It is activated by applying voltage of 400V, and the displacement of 60-layer artificial muscles is ~3.0mm, with contraction strain of ~10%, and the maximum output force is ~50kPa. The response rate is 9Hz, and the current is about 0.45mA.

**Biomimetic robot system for plumbing tests**
**Tempuu Siva, Teruo Toyoda, and Fujio Mine, Haloworld Inc., Fukushima (Japan)**


A tubular inchworm robot mechanism that is driven by electroactive polymer and air pressure will be presented. This robot will be equipped with a camera to allow testing the plumbing of the decommissioned Fukushima Daiichi Nuclear Power Plant. The robot is capable of traversing thru the many elbow sections along the more than several hundred meter plumbing. The use of the EAP actuation mechanism allows for smooth operation through the curvatures along the plumbing path.

**Multilocation sensing on one input/output and EAP zoo**
**Markus Henke, Patrin Illenberger, Katie Wilson, Andreas Tairych, Chris Walker, Antoni Harbuz and Iain Anderson, Biomimetic Lab, Auckland Bioengineering Institute (New Zealand)**

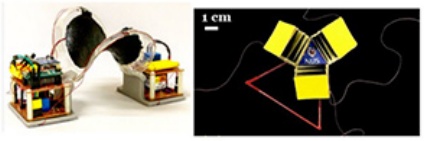


The Biomimetics Lab presents:
1. The multisensor shirt that can measure stretch at several locations from one input/output
2. The Electroactive polymer zoo: we present the latest self-regulating crawling caterpillars and wing-flapping dragonflies fabricated from printed polymer and electrode. No need for electronics!

**New EAP products**
**Antoni Harbuz and Iain Anderson, StretchSense, Ltd. (New Zealand)**

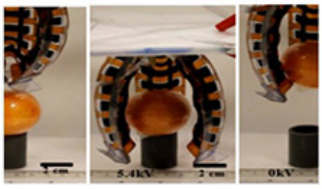
What's new in wearable electroactive polymer sensing and energy harvesting

**Soft untethered robots**
**Godaba Hareesh, Jiawei Cao, Jian Zhu, Nanyang Technological Univ. (Singapore)**



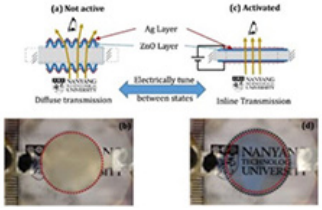

Soft untethered robot will be demonstrated that mainly consists of a deformable robotic body and two paper-based feet (Figure 1). Based on the optimal mechanical design, the robot is capable of achieving autonomous movements. In addition, an origami-based soft robot will be demonstrated (Figure 2)

**Dielectric elastomer grippers using tensioned arch flexures**
**Anansa S. Ahmed and Lau Gih Keong, Nanyang Technological Univ. (Singapore)**



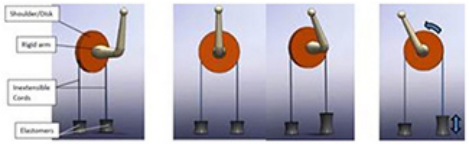

The followings are going to be demonstrated:
1. Versatile DEA grippers with enhanced tip angle deflection and blocked force due to tension arch flexure structure
2. Grippers capable of grasping and lifting a variety of objects including highly deformable materials without damage.

**Electrically tuning transparency by wrinkling of ZnO/Ag thin film**
**Milan Shrestha, Rosmin Elsa Mohan, Anansa Ahmed, Anand Asundi, Gih-Keong Lau, Nanyang Technological Univ. (Singapore)**



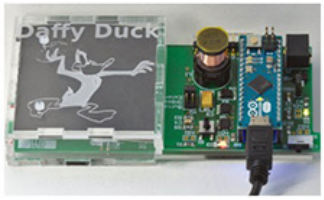

This demonstration unit consists of transparency tunable device. It works based on wrinkling and unfolding a ZnO/Ag-coated elastomer substrate using a dielectric elastomer actuator (DEA). Initially, the membrane is at wrinkled state and the device is opaque. An object placed underneath the membrane will not be visible. When the DEA device is electrically activated, the wrinkles are flattened turning the device to a transparent membrane and the object placed behind the device becomes clearly visible. Reversible tuning between the two states can be obtained electrically for a large number of cycles.

**A stackable and configurable antagonistic actuator system for a wrestling arm**
**Koh Soo Jin Adrian, Stoyan Smoukov, Ang Marcelo H. Jr., Vy Khanh Vo Tran, Anup Teejo Mathew, Lionel Chong, Lester Leong, National Univ. of Singapore (Singapore) and Cambridge Univ. (United Kingdom)**



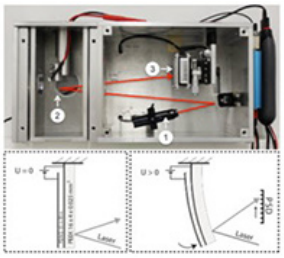
Two stackable loudspeaker-type dielectric elastomer actuator (DEA) modules which have continuous-tuneable movement by voltage will be demonstrated. When voltage is continuously switched between two DEA modules, the linear motion will be transferred to the controllable rotation of the arm with the extra mechanical design. During operation, a voltage is applied across the elastomer on the right, causing it to expand and “relax”. The elastomer on the left contracts due to tension in itself, pulling on the disc and rotating the arm anti-clockwise. No voltage is applied across the left elastomer. The force exerted by the left elastomer is determined by the pre-stretching done mechanically. A discharge circuit also be included to remove the charge stored in DE membrane immediately once turning off voltage to get faster actuation, hence increases the power for the arm.

**PetaPicoVoltron: an open-source portable high-voltage supply**
**Samuel Rosset and Samuel Schlatter, EFPL (Switzerland)**



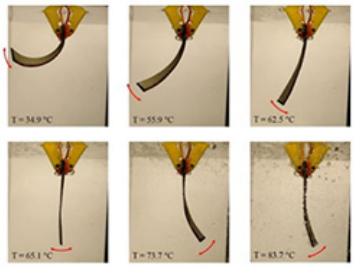

A portable high voltage power supply (HVPS) will be demonstrated that is specifically designed to drive DEAs. Its output DC voltages is up to 5kV with a resolution of 0.1% of full scale, and can generate square signals from 1mHz to 1kHz with a slew rate faster than 15V/µs. It has a user friendly GUI enabling easy interaction with the HVPS, and using LabView library makes it simple to integrate the power supply with other instruments. The circuit layout and the software have been released as an open-source project, for anyone to use and improve.

**Apparatus for measuring the actuation forces of DEAs via cantilever bending**
**Bekin Osmani, Tino Topper, Burt Miller, Univ. of Basel (Switzerland)**



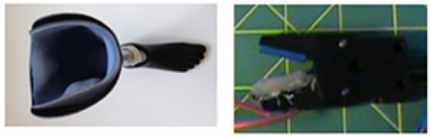
A compact, simple-to-operate apparatus for measuring the generated forces of planar dielectric elastomer actuators (DEA) will be demonstrated. DEA structures are fabricated on top of a cantilever substrate material with well-known mechanical properties such as PEN, PEEK, or Kapton film. When a DC-voltage is applied to the planar electrodes on either side of the elastomer layer, the resulting deformation of the incompressible elastomer bends the cantilever. The bending curvature is measured by the deflection of a laser beam reflected from the cantilever onto a position sensitive detector. This cantilever system can be used to evaluate the maximal strains of single- as well as multilayer DEAs. Light from a laser (1) reflects off from a DEA-based cantilever (2). When a DC-voltage is applied, the cantilever bends (bottom schematic). A position sensitive detector (3) measures the resulting deflection of the laser beam.

**Development of an origami soft robot using multiple shape memory ionic polymer-metal composite**
**Qi Shen, Sarah Trabia, Tyler Stalbaum, Taeseon Hwang, Robert Hunt, Zakai Olsen, Kwang Kim, Univ. of Nevada, Las Vegas (United States)**



The multiple-shape-memory ionic polymer-metal composite (MSM-IPMC) actuator is used to demonstrate complex 3D deformation. The MSM-IPMC has two characteristics, which are the electro-mechanical actuation effect and the thermal-mechanical shape memory effect. The bending, twisting, and oscillating motions of the actuator could be controlled simultaneously or separately by means of thermal-mechanical and electro-mechanical transactions. Using the MSM-IPMC, a soft biomimetic robot was developed that has origami structure. The multiple shape memory effect enables the robot to change its shape and in return enables the robot to move forward in water. This work may bring inspiration for designing new soft robotic systems with the MSM-IPMC actuators.

**Synthetic Muscle: shape-morphing and sensing EAP based materials and actuators**
**Lenore Rasmussen, Ras Labs LLC (United States)**



The operation or the latest Synthetic Muscle™ based actuators will be demonstrated. These are actuators that contract and expand, attenuate impact, and sense pressure. Actuation will be performed underwater, on land with suitable elastomeric coatings, and impact (mechanical pressure) resistance demonstrated. Also, prosthetic liner prototype with self-adjusting EAP based pads and sensing robotic gripper will also be demonstrated.

## 3D Printing Demonstration Session

Date: **Monday 27 March 2017**
Time: **4:00 PM - 6:00 PM**

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**Part of conference 10167 on Nano-, Bio-, and Info-Tech Sensors and 3D Systems. Review the full conference program here.**

Session Chairs:

**Ajit Khosla**
Yamagata Univ. (Japan)

**Hidemitsu Furukawa**

Yamagata Univ. (Japan)

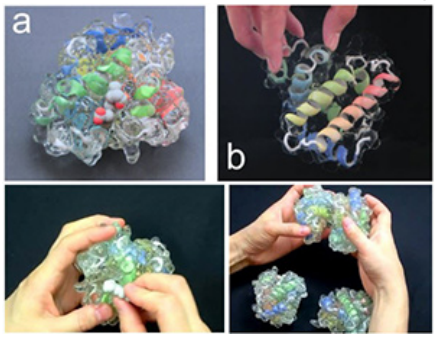
This demonstration session will cover new 3D printing technologies such as focusing on soft robotics, molecular models, and food. Each demonstration will include a brief oral talk describing the technology. All registered attendees are welcome.

Tentative Demonstrations:

**The flexibility controlling study for 3D printed splint**
**Jianyou Li, Hiroya Tanaka, Keio Univ. (Japan)**
The concept of 3D printed splint appeared in few years ago, and its light weight and ventilation can improve the comfortableness for patients. In this study, two main techniques to control the infilling densities and printing temperature are applied on printing splint prototype. The gradual increasing of infilling density from splint outside to inside would turn the partial strength from hard to flexible. Besides, higher printing temperature can also achieve stronger hardness after cooling. Such structural can provide high strength in outside surface to keep the immovable function, and give flexible touch of inside surface to decrease friction on the patient's skin.

**3D printing and IoT for personalized everyday objects in nursing and healthcare**
**Yoshihiro Asano, Hiroya Tanaka, Shoko Miyagawa, Junki Yoshioka, Keio Univ. (Japan)**
Today, 3D printing in medical use are mainly focusing on the symptom itself, not on everyday lives of patients. However, with life span extending, many of us will live a life with chronic disease for long time. To support their lives, we use 3D printing for making everyday objects from a nursing / healthcare perspective. In our project, we invited many kinds of people such as engineers, nurses and patients to our research activity and found methodologies for collaboration. Also we're developing the IoT sensing system, which monitor activities of 3D printed objects remotely.

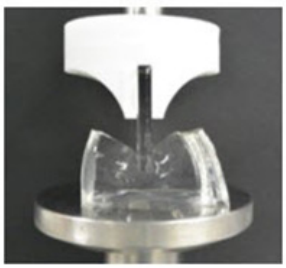
**3D printing of protein molecules**
**Masaru Kawakami, Hidemitsu Furukawa, Yamagata Univ. (Japan)**




Protein molecules play many critical roles in our body. They have large and complex structures, and understanding of the relationship between their structures and biological functions is a crucial key for biology and medicines. At the present, to conceptualize structures of proteins, we rely on computer graphics of their three-dimensional (3D) structure. On the other hand, physical models can convey "intuitive" understanding, and that is really useful for education and even for peer discussion. The first author Kawakami invented a new molecular model called "Kawakami model", which is a soft, transparent handleable model, can be fabricated by 3D printing and transparent silicone resin. A full-color printed amino acid chain structure is embedded in the silicone body. The silicone body represents the molecular surface of a protein molecule. Users can simultaneously feel the molecular surface, view through the main chain structure, and even manually simulate molecular docking. This model is already commercialized and available upon request. So far many Kawakami models have already been shipped and being used as effective discussion tools for the classroom/laboratory, exhibition in museums/institutes, and outreach activities. In this session, some Kawakami models will be presented, and demonstration of "hands-on" protein-ligand docking and protein-protein interaction will be performed.

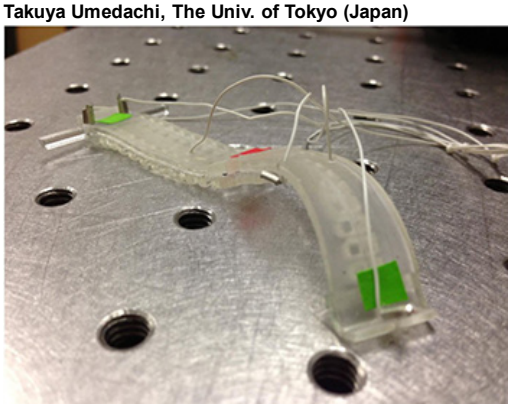
**Smart walking stick for blind people: an application of 3D printer**
**Faidur Rahman, Md. Allama Ikbal, Univ. of Rajshahi (Bangladesh); Md. Hasnat Kabir, Hidemitsu Furukawa, Yamagata Univ. (Japan)**
A prototype of the smart walking stick has been designed and characterized for the people who are visually impaired. The proposed system was designed into two stages, i.e. hardware and software. Two ultrasonic sonar sensors were used to detect in front obstacle and street surface obstacle such as a manhole. The distance between sensor and the obstacle is calculated by the received signal. The calculated distance value is compared with the pre-defined value and determines whether the obstacle is present or not. An Up-Mini 3D printer was used to print the sensor holders which were mounted on the walking stick. Therefore, the sensors were fixed in the right position. Another sensor was used for the detecting the water on the walking street. The performance for detecting the obstacles and water indicate the merit of the smart walking stick.

**3D gel printing and applications**
**Kazuyuki Sakai, Masato Wada, Kyuuichiro Takamatsu, Azusa Saito, Ajit Khosla, Masaru Kawakami, Hidemitsu Furukawa, Yamagata Univ. (Japan)**



We have developed 3D gel printer from 8 years ago. Around two thousand years ago, high strength gels were invented by Japanese researchers. However, it was difficult to process high strength gels (Fig. 1), because gel is soft material and complex synthesis procedures are needed. In SWEL, we develop a new type of high strength gels (ICN4), P-DN5)), which can be used for 3D gel printer. Furthermore, we developed two types of 3D gel printer, “Bathtub type” and “Dispenser type” in Strategic Innovation promotion Program (SIP) supported by cabinet office, government of Japan. Figure 2 shows 3D models made by high strength gels. Not only 3D gel printer, we have studied another processing methods using laser cutter, using mold. Figure 3 shows 3D gel printers. Another side of important specific of high-strength gel is low friction. Taking this advantage, we have studied gel-sheet, gel-O-ring, and so on. The apparatus of Fig.4 is gel friction meter to measure friction and/or toughness of the gel. This is also supported by the national project named “Green Tribology Innovation Network” in the area of Advanced Environmental Materials, Green Network of Excellence (GRENE). We will show samples made by high strength gels in the demo session.

**Caterpilike: a soft-bodied 3D printed robot inspired by caterpillars**
**Takuya Umedachi, The Univ. of Tokyo (Japan)**



Caterpilike is a soft-bodied 3-d printed robot inspired by caterpillars. Caterpillars are excellent living models to extract the mechanical and control design principles for soft-bodied robots, since they produce adaptive and resilient behaviors by orchestrating the large degrees of freedom in their bodies (no explicit skeletons) with small numbers of neurons. Compared with traditional robotic systems consisting of hard-rigid components, the robot generates crawling locomotion driven by a few actuators by exploiting the continuum large-deformation of the soft material. We believe that such body design is important to endow a robotic system to have high an affinity with our living and natural environments.

**3D printing in social education: Eki-Fab and student PBL**
**Masato Makino, Azusa Saito, Mai Kodama, Kyuuichiro Takamatsu, Hideaki Tamate, Kazuyuki Sakai, Masato Wada, Ajit Khosla, Masaru Kawakami, Hidemitsu Furukawa, Yamagata Univ. (Japan)**

Additive manufacturing or 3D printer is one of the most innovative material processing methods. We are considering that 3D printing human resources would be needed in the world in the future. To educate the abilities of the digital fabrication, we have the public digital space “Eki-Fab” for junior and high school students and Project Based Learning (PBL) class for bachelor course students. Eki-Fab is held on Saturday in the 2nd floor of the Yonezawa train station. In the “Eki-Fab”, anybody can study the utilizing of 3D printer and its related modeling technics under the instruction of staff in Yamagata University. In the PBL class, we have the class every Thursday. The students get the techniques of the digital fabrication through the PBL.

**3D printing for food**
**Mai Kodama, Azusa Saito, Masato Makino, Ajit Khosla, Masaru Kawakami, Hidemitsu Furukawa, Yamagata Univ. (Japan)**

We have been developing a new food by using the 3D printer in cooperation with local companies. Now, we would like to introduce two types of new products was realized in this effort as shown in Fig.1 and Fig.2. Fig.1 is a jelly with the form of a carp. This jelly is melted if you soak it in the hot water, so you can eat it as a soup. Fig. 2 is a jelly with the form of a lantern. Since this jelly does not melt even at high temperatures, you can eat as warm jelly. These jellies were formed by molds made by using the 3D printer as shown in Fig. 3. We made the jellies with the form of a carp and a lantern, because locals likes carps and lanterns. Carp has been eaten for a long time following economical instructions of the then governor. Because our local area receives a lot of snow in the region, there is a festival to make a lot of snow lanterns. If the practical application of the 3D printer is advanced, everyone can make the original food easily, and everyone may enable obtaining enjoyment of eating.

**Direct material weaving by G-code manipulation**
**Soko Koda, Hiroya Tanaka, Keio Univ. (Japan)**

**Polymer-based blood vessel models with micro-temperature sensors in EVE**
**Mizue Mizoshiri, Yasuaki Ito, Takeshi Hayakawa, Junpei Sakurai, Seiichi Ikeda, Fumihito Arai, Seiich Hata, Nagoya Univ. (Japan)**

**3D printing of wearable fractal based sensor systems for neurocardiology and healthcare**
**Vijay K. Varadan, Mouli Ramasamy, The Pennsylvania State Univ. (United States)**
Neurocardiology is the pathophysiological interplay of nervous and cardiovascular systems. The communication between the heart and brain has revealed various methodologies in healthcare that could be investigated to study the heart-brain interactions and other cardiovascular and neurological diseases. A textile-based wearable nanosensor system in the form of e-bra, e-shirt, e-headband, e-brief, underwear etc. was presented in SPIE conferences earlier for noninvasive recording of EEG and EKG, and showing the correlation between the brain and heart signals. In this paper, the technology is expanded further using fractal based geometries using 3D printing system for low-cost and flexible wearable sensor systems for healthcare.